YAKEEN

Lecture - 10

Some Basic Concept of Chemistry

By

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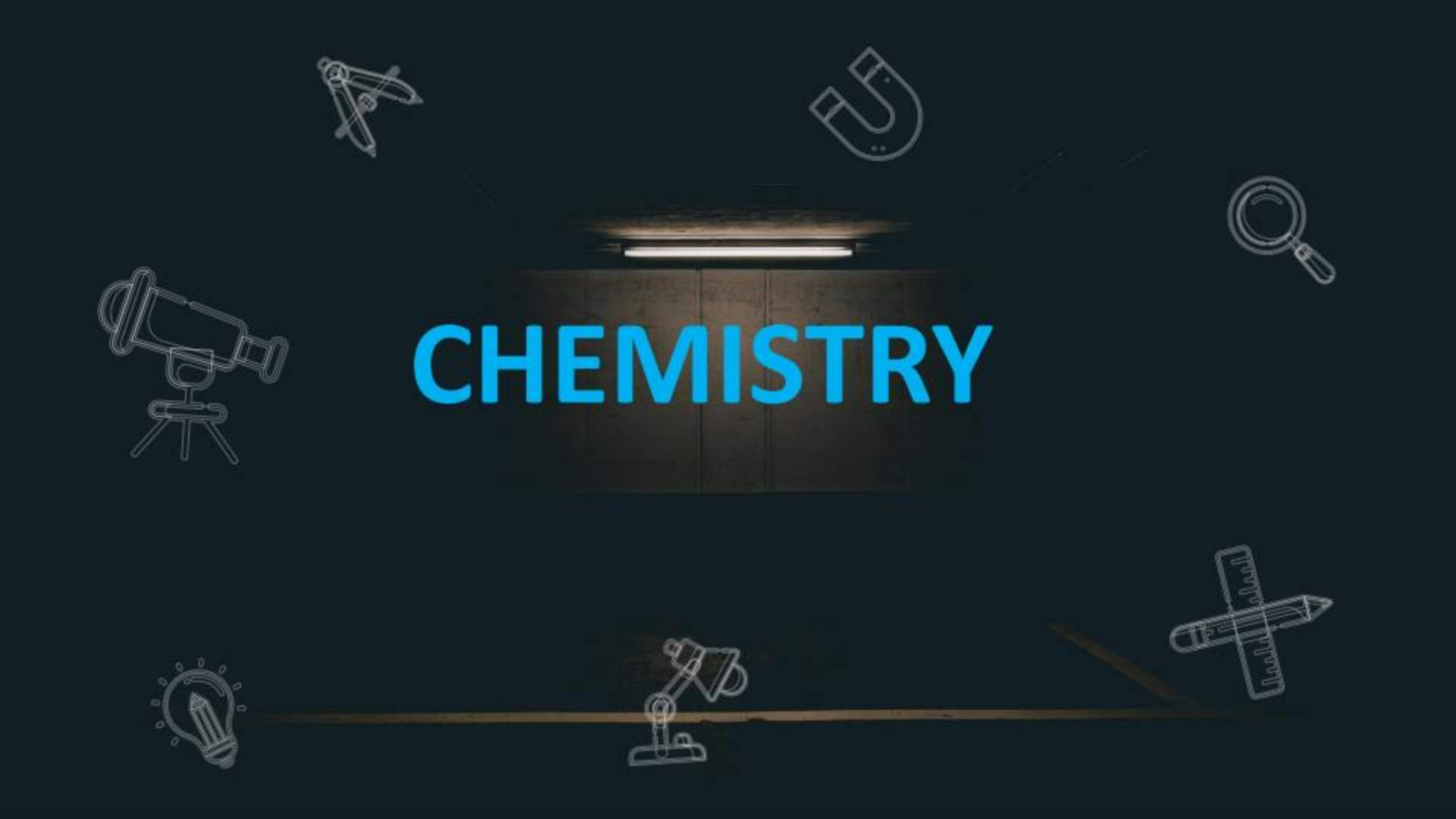

CHEMISTRY

TODAY'S GOAL

- DILUTION EQUATION
- MOLARITY OF MIXTURES OF SOLUTIONS
- PARTS PER MILLION (PPM)
- EQUIVALENT MASS
- LAW OF EQUIVALENCE → Next Class

How many grams of 70% (w/w) concentrated nitric acid solution should be used to prepare 250 mL of 2.0 M HNO_3? [NEET 2013]

(a) 54.0 g conc. HNO_3
(b) 45.0 g conc. HNO_3
(c) 90.0 g conc. HNO_3
(d) 70.0 g conc. HNO_3

As 70g of solute (HNO_3) is present in 100g of Conc. HNO_3

$HNO_3 \rightarrow$ $M = 2M$

$V = 250 ml$

$M_B = 63 g$.

$$M = \frac{W_B \times 1000}{M_B \times \text{Vol. of soln (ml)}}$$

$$2 = \frac{W_B \times \cancel{1000}^{\,4}}{63 \times \cancel{250}}$$

$$\frac{\cancel{126}^{\,63}}{\cancel{4}_{\,2}} = W_B \Rightarrow \boxed{W_B = 31.5\,g}$$

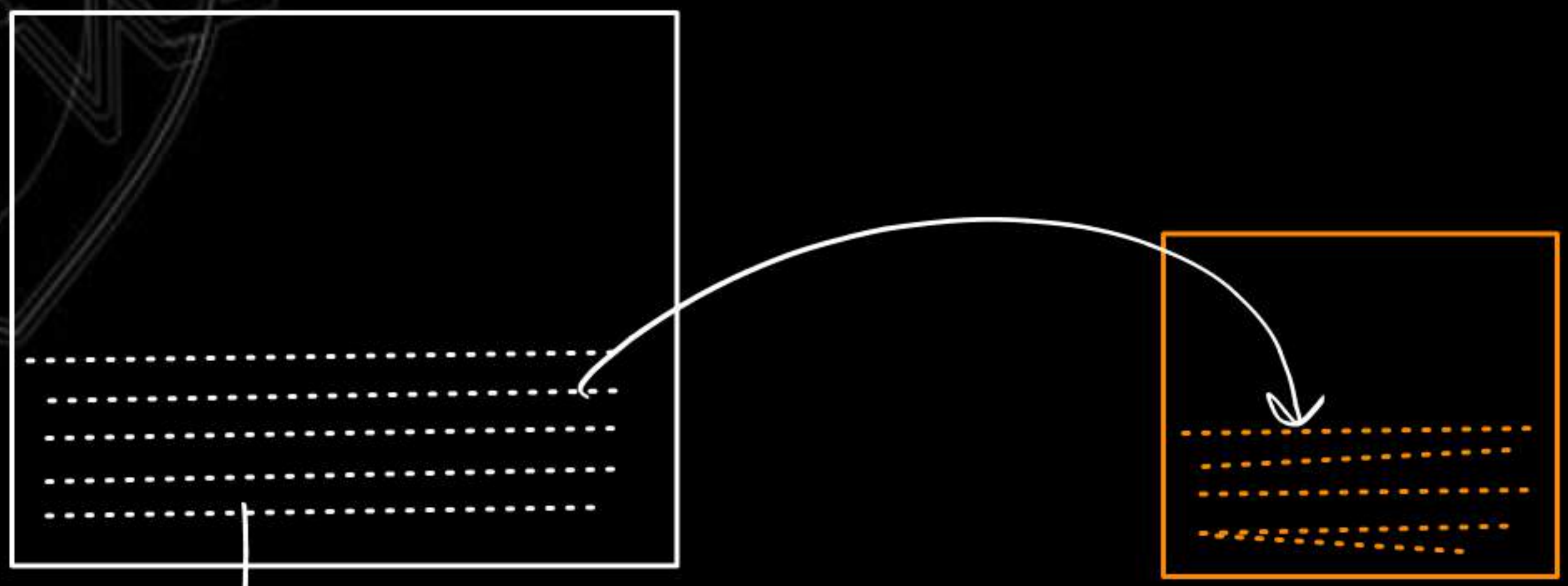
70 g of HNO_3 is present in Conc. HNO_3 = 100 g.

31.5 g of HNO_3 is present in Conc. HNO_3

$$= \frac{10\cancel{0}}{7\cancel{0}} \times 31.5$$

= 45 g of Conc. HNO_3

Dilution Equation



Conc. HCl

12 M

Moles of solute before dilution = moles of solute after dilution.

$$M_1 V_1 = M_2 V_2$$

M_1 = Molarity Conc. solution.

V_1 = Vol. of Conc. solution.

V_2 = Vol. of dilute solution

M_2 = Molarity of dilute solution.

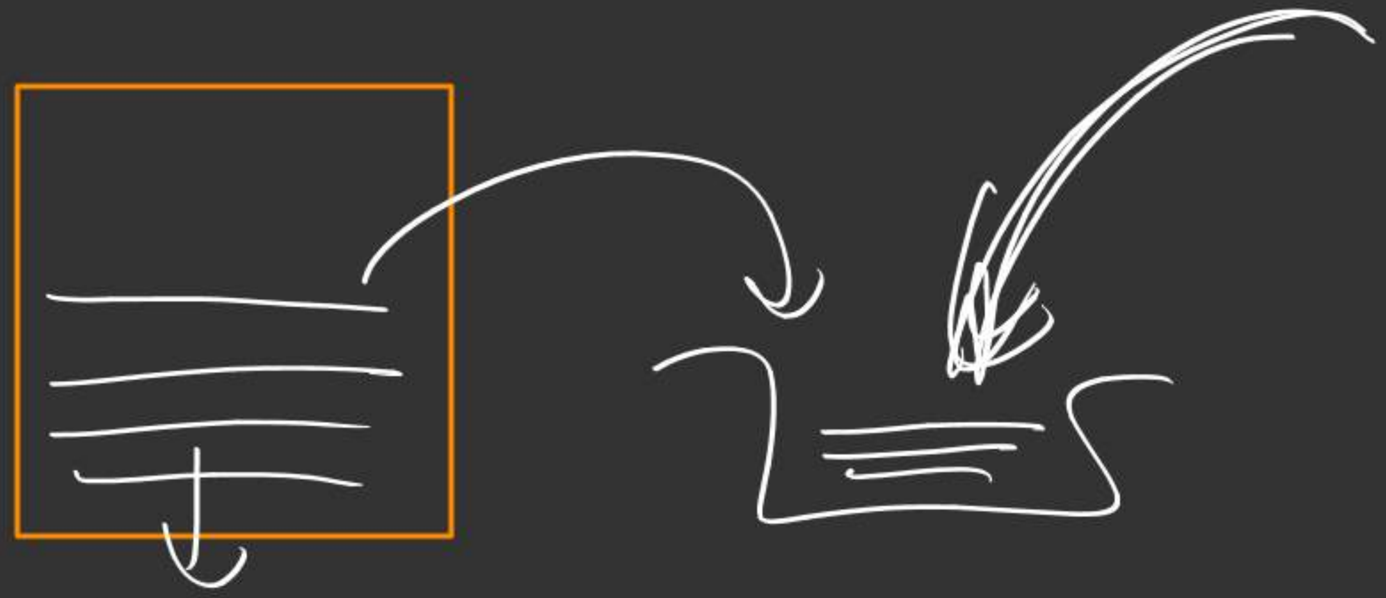
$$M = \frac{n}{V(L)}$$

$$n = M \times V(L)$$

Q. What Volume of 12 M HCl is required to prepare 500 ml of 3 M HCl?

$\downarrow M = \frac{n}{V \uparrow}$

Ans



$M_1 = 12\,M$

$V_1 = ?$

$V_2 = 500\,ml$

$M_2 = 3\,M$

$M_1 V_1 = M_2 V_2$

$\overset{4}{\cancel{12}} \times V_1 = \cancel{3} \times 500$

$$\boxed{V_1 = \frac{500}{4} = 125\,ml}$$

Concentrated aqueous solution of sulphuric acid 98 % H_2SO_4 by mass and has a density of $1.80\ g\ mL^{-1}$. Volume of acid required to make 1 litre of $0.1M\ H_2SO_4$ solution is: [AIPMT 2007]

(a) $11.10\ mL$
(b) $16.65\ mL$
(c) $22.20\ mL$
(d) $5.55\ mL$

$M_B = 98g$

Ans

Conc. H_2SO_4

98 % H_2SO_4 by mass

d of soln $= 1.8\ g/ml$

$V_1 = ?$

$V_2 = 1L = 1000\ ml$

$M_2 = 0.1M$

$M_1 = \frac{\cancel{98} \times 1.8 \times 10}{\cancel{98}} = 18\ M$

$$M_1 V_1 = M_2 V_2$$

$$18 \times V_1 = 0.1 \times 1000$$

$$V_1 = \frac{100}{18} = 5.55\, ml$$

Molarity of Mixtures

→ same nature
same substance

HCl + HCl = HCl

$n_1 + n_2 = n_3$

$M_1V_1 + M_2V_2 = M_3V_3$ $(V_3 = V_1 + V_2)$

$n = M \times V(L)$

$$\boxed{\underline{M_3} = \frac{M_1V_1 + M_2V_2}{V_3}} \quad (V_3 = V_1 + V_2)$$

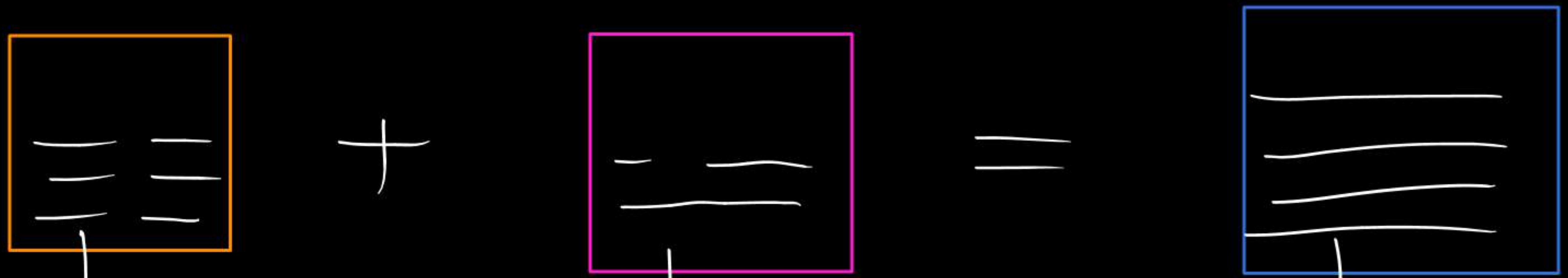
$\downarrow$

Same substances added

Two solutions of a non-electrolyte are mixed in the following manner:
480 mL of 1.5 M first solution +520 mL of 1.2 M second solution. What is the molarity of the final mixture? [AIIMS 2011]

(a) 2.70 M
(b) 1.344 M
(c) 1.50 M
(d) 1.20 M

As



$V_1 = 480\,ml$
$M_1 = 1.5\,M$

$V_2 = 520\,ml$
$M_2 = 1.2\,M$

$M_3 = ?$
$V_3 = V_1 + V_2$

$$M_3 = \frac{M_1 V_1 + M_2 V_2}{V_3}$$

$$\left(\begin{array}{l} V_3 = V_1 + V_2 \\ V_3 = 480 + 520 \\ V_3 = 1000 \end{array} \right)$$

$$M_3 = \frac{1.5 \times 480 + 1.2 \times 520}{1000}$$

$$\begin{array}{r} 720 \\ 624 \\ \hline 1344 \end{array}$$

$$M_3 = \frac{\frac{3}{\cancel{2}} \times \overset{240}{\cancel{480}} + \frac{12}{1\cancel{0}} \times 52\cancel{0}}{1000}$$

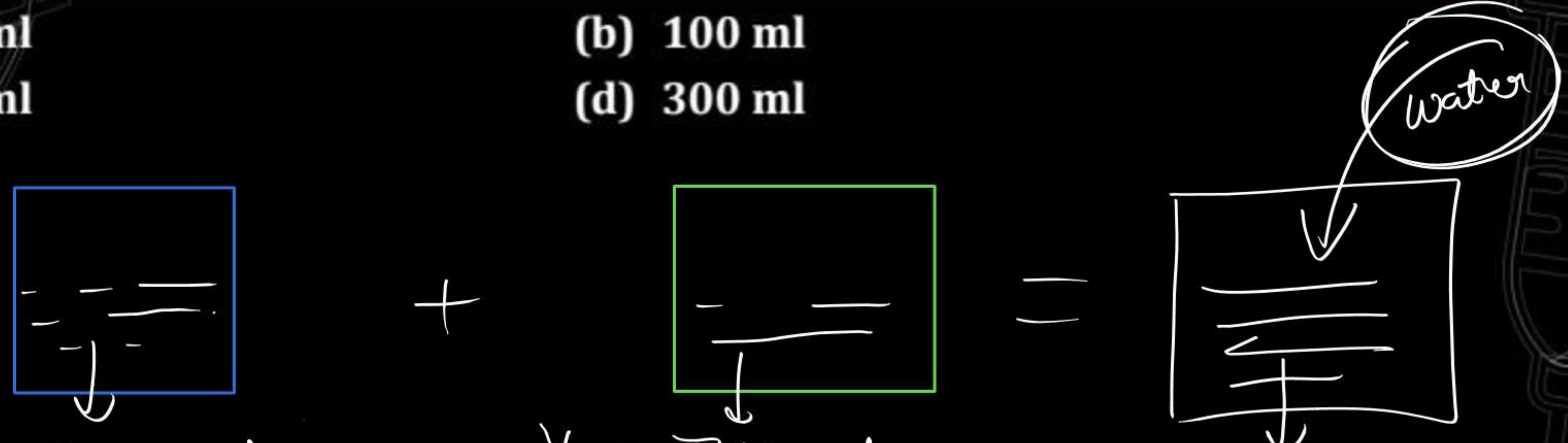
$$\boxed{M_3 = \frac{1344}{1000} = 1.344\,M}$$

The volume of water that must be added to a mixture of 250 ml of 0.6 M HCl and 750 ml of 0.2 M HCl to obtain 0.25 M solution of HCl is :

(a) 750 ml (b) 100 ml

(c) 200 ml (d) 300 ml

Ans



$V_1 = 250\,ml$, $M_1 = 0.6\,M$

$V_2 = 750\,ml$, $M_2 = 0.2\,M$

$M_3 = 0.25\,M$

$V_3 = a\,ml$

$$M_3 V_3 = M_1 V_1 + M_2 V_2$$

$$M_3 = \frac{0.6 \times 25\cancel{0} + 0.2 \times 75\cancel{0}}{a}$$

$$M_3 = \frac{300}{a} = 0.25$$

$$\frac{300 \times \overset{4}{\cancel{100}}}{0.\cancel{25}} = a \Rightarrow \boxed{a\,ml = 1200\,ml}$$

Total Valume = 1200 ml

Vol. of water adddd = 1200 − 750 − 250

= 200 ml

Parts per million (ppm)

10 ppm by mass of HCl

10 g of solute (HCl) is present in 10^6 g of solution.

80 ppt by mass (w/w) of HCl (solute)

80 g of solute is present in 1000g of solution.

HNO_3

25 ppm by Volume (V/V)

25 ml of solute (HNO_3) is present in 10^6 ml of solution.

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32 ppm by strength (w/V)

$NaOH$

32 g of solute ($NaOH$) is present in 10^6 ml of solution.

$$\underline{\underline{ppm}} = \frac{\text{parts of solute}}{\text{parts of solution}} \times 10^6$$

Q A sample of drinking water has 15 ppm of $CHCl_3$ by mass.

(Molar mass of $CHCl_3 = 119.5$ g)

(a) express this in %-age by mass

(b) also find molality of solution.

$\rightarrow$ $CHCl_3$ 15 ppm by mass.

(a) $\text{\%-age of } CHCl_3 = \frac{\text{mass of } CHCl_3}{\text{mass of solution}} \times 100$

15 ppm
of $CHCl_3$ by mass

15 g of $CHCl_3$
present in 10^6 g
of solution.

$\text{\%-age of } CHCl_3 = \frac{15}{10^6} \times 100$

$\text{\%-age of } CHCl_3 = 15 \times 10^{-4}$

(b) $m = \dfrac{W_B \times 1000}{M_B \times W_A (\text{in } g)}$

$W_B = 15\,g$

$M_B = 119.5\,g$

$W_A \simeq 10^6\,g$

$m = \dfrac{15 \times 1000}{119.5 \times 10^6}$

$$\boxed{m = \frac{15}{119.5} \times 10^{-3}}$$

Equivalent mass

mass of substance which will react or produce or displace

CO_3^{2-}

1g of Hydrogen or 8g of Oxygen

or 35.5g of Chlorine or 23g of Na

or 17g of OH^- or 30g of CO_3^{2-}

Or ______ g of Ca

$$1\,C + 2\,H_2 \longrightarrow 1\,CH_4$$

1 mole of C | 2 moles of H_2 | 1 mole of CH_4

12g of C | 4g of H_2 | 16g of CH_4

1 mole has mass = Molar mass

^1_1H

$M_{H_2} = 2g$

4g of H_2 react with C = 12g

1g of H_2 react with C = $\frac{12}{4}$ = 3g is eq. mass of C in this r^n

4g of H_2 $\longrightarrow$ 16 g CH_4

1 g $\longrightarrow$ $\frac{16}{4} = 4$g is eq. mass of CH_4 in this r^n.

$1 N_2 + 3H_2 \longrightarrow 2NH_3$

1 mole   3 mole   2 moles.

28g $\longleftarrow$ 6 g. $\longrightarrow$ 34 g.

$M_{H_2} = 2g$

$M_{N_2} = 28g$

$M_{NH_3} = 17g$

$6g \xrightarrow{H_2} 28g$ of N_2

$1g\ H_2 \longrightarrow \boxed{\frac{28}{6}g \text{ of } N_2}$

Eq. mass of N_2 in this r^n.

$6g\ H_2 \longrightarrow 34g\ NH_3$

$1g\ H_2 \longrightarrow \frac{34}{6} = \frac{17}{3}g$ of NH_3

✓ $\frac{17}{3}g$ is eq. mass of NH_3 in this r^n

$$1C + \frac{1}{2}O_2 \rightarrow 1CO$$

1 mole $\quad \frac{1}{2}$ mole $\quad$ 1 mole

$12g \leftarrow 16g \longrightarrow 28g$

$\cancel{8} \times \frac{12}{\cancel{16}_2} \leftarrow 8g \longrightarrow \frac{28}{\cancel{16}_2} \times \cancel{8}$

6g is eq. mass of C in this r^n.

= 14g is eq. mass of CO in this r^n.

$M_C = 12g$

$M_{O_2} = 32g$

$M_{CO} = 28g$

$$\boxed{\text{eq. mass or eq. weight} = \frac{\text{Molar mass}}{n_{factor} \text{ or Valency factor}}}$$

Find n-factor or valence factor for different substance

For acids n-factor = Basicity

Basicity = no. of H^+ ions given by 1 molecule of acid.

$$\underline{1}HCl + 1H_2O \longrightarrow \underset{\text{or } 1H_3O^+}{\underline{1H^+}} + 1Cl^-$$

$n_f = 1$

$$\text{eq. mass of } HCl = \frac{M_{HCl}}{n_{factor}} = \frac{36.5}{1} = 36.5g$$

$$1H_2SO_4 + H_2O \longrightarrow 2H^+ + 1SO_4^{2-}$$

n_{factor} of $H_2SO_4 = 2$

Eq. mass of $H_2SO_4 = \frac{98}{2} = 49\,g$

Proti acid → substance which gives it's H^+ in water.

Acids	n-factor
HCl, HNO_3, H_3PO_2 H_3BO_3 or $B(OH)_3$	1
H_2SO_4, H_3PO_3	2
H_3PO_4	3

$\boxed{H_3PO_2,\ H_3PO_3,\ H_3PO_4}$

$\downarrow$

$n_f = $ no. of oxygen atoms $- 1$

H_3BO_3 (Boric acid)

or $B(OH)_3$

$$B(OH)_3 + H_2O \longrightarrow B(OH)_4^- + 1H^+$$

Boric acid is not a protic acid

$n_f = 1$

For Bases n-factor = Acidity

Acidity = no of OH^- given by 1 molecule of Base.

$$\underset{\substack{\downarrow \\ n_f = 1}}{\underline{NaOH}} + H_2O \rightarrow 1Na^+ + 1OH^-$$

$$Ba(OH)_2 + H_2O \rightarrow 1Ba^{2+} + 2OH^-$$

$n_f = 2$.

Bases	n_f
$NaOH$, KOH	1
$Ba(OH)_2$	2
$Al(OH)_3$	3

For ions n-factor = |Charge on ion|

$CO_3^{2-} \Rightarrow n_f = |-2| = 2$

Eq. mass of $CO_3^{2-} = \frac{60}{2} = 30g$

$OH^- \Rightarrow n_f = |-1| = 1$

Eq. mass of $OH^- = \frac{17}{1} = 17g$

Al^{3+}
$\Downarrow$
$n_f = 3$

Eq. mass of Al^{3+}
$= \frac{27}{3} = 9g$

For elements n-factor = | valency|

$Na \longrightarrow Na^+ + 1e^-$

$\downarrow$

$n_f = 1$

eq. mass of Na

$= \frac{23}{1} = 23g$

$O + 2e^- \rightarrow O^{2-}$

$n_f = 2$

eq. mass of oxygen $= \frac{16}{2} = \frac{32}{4} = 8$

$H \rightarrow H^+ + 1e^-$

$\downarrow$

$n_f = 1$

eq. mass of Hydrogen

$= \frac{1}{1} = \frac{2}{2} = \frac{1}{1}$

$Cl + 1e^- \rightarrow Cl^-$

$\downarrow$

$n_f = 1$

eq. mass of Chlorine

$= 35.5g$

The equivalent weight of oxygen, when it is converted to oxide, is equal to [AIIMS 1995]

(a) $\frac{\textit{Molecular weight}}{3}$

(b) *Molecular weight*

(c) $\frac{\textit{Molecular weight}}{4}$

(d) $\frac{\textit{Molecular weight}}{2}$

Eq. mass of O_2 = $\frac{\text{molecular weight}}{4}$

For ionic compounds n-factor = |Charge on cation or anion|

$\overset{+}{Na}\overset{-1}{Cl} \longrightarrow n_f = 1$

$\overset{2+}{Ca}\overset{-1}{Cl_2} \longrightarrow n_f = 2$

$\overset{+2}{Ca}\overset{-2}{SO_4}$

$\downarrow$

$n_f = 2$

Eq. mass of $CaSO_4 = \frac{136}{2} = 68g$.

Gram equivalents

$$\underset{(g.\,eq.)}{\text{gram equivalent}} = \frac{\text{mass } (w)}{\text{eq. mass } (E)}$$

Q find no. of gram equivalents in 73 g of HCl?

As $g.eq. = \dfrac{\text{mass of HCl}}{\text{eq. mass of HCl}}$

$= \dfrac{73}{36.5} = 2$

$HCl \rightarrow n_f = 1$

$\text{eq. mass of HCl} = \dfrac{36.5}{1}$

Normality (N) – Number of gram equivalents of solute present in 1L of solution

$$N = \frac{\text{no. of g-eq. of solute}}{\text{Volume of solution (in L)}}$$

unit of N = geq/L
or Normal

$$\boxed{N = \frac{w_B \times 1000}{E_B \times \text{Vol. of solution (in ml)}}}$$

w_B = mass of solute

E_B = eq. mass of solute

Relation b/w Normality & Molarity

$$N = \frac{w_B \times 1000 \times n_f}{M_B \times \text{Vol. of sol}^n \text{(ml)}} \quad \Bigg| \quad E_B = \frac{M_B}{n_f}$$

$$\boxed{N = M \times n_f}$$

Terms which do not depend upon Temp.

Molality, mole-fraction, % by mass

better method to represent Concentration.

Terms which depend upon Temp.

Molarity, Normality, %age by Volume, % by strength

thanks
for watching